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# JANUS Interface Specifications

## (Symmetrical, 1822-like Interface)

## 1. INTRODUCTION

### 1.1. Motivation

A need arose in the Packet Radio project for specification of an interface between Packet Radio units and other equipment. This paper is to meet BBN's responsibility to supply that specification. It is our hope that it will find application in other areas as well.

### 1.2. Historical Relationship to 1822

The ARPANET employs a network of switching nodes, called IMPs, to provide interconnection among user equipment, called hosts. A uniform means of connecting a host to an IMP is specified in BBN Report Number 1822. Consequently, this interface has become known as an 1822 interface.

As the need to interconnect new types of devices has grown, it has become attractive to implement an 1822-like interface on each end of pairs of devices which are to communicate. The devices are then connected electrically, and communication can take place in spite of differences in processing speed, word length, signal levels and so forth in the two devices. A part of Report 1822 reads as follows.

> "The technique of transferring information between the Host and the IMP is identical in each direction; we will, therefore, refer to the sender and the receiver without specifying the Host or IMP explicitly."
> [BBN Report Number 1822, 12/75 revision, page 4-2.]

Unfortunately, Report 1822 does not specify a completely symmetrical interface. Although there is a high degree of symmetry, some aspects are peculiar to the IMP side and some to the host side. Therefore, two interfaces constructed to connect to IMPs may not function connected to each other. In what follows, the unsymmetrical aspects are respecified in a way which will accomplish full interchangeability.

The interface specified here is called the JANUS interface, to distinguish it from the Report 1822 interface.

### 1.3. Terminology

The terms, "IMP" and "host," are not relevant in the present context. Sections of Report 1822 such as Appendix B are conveniently re-interpreted by substituting "foreign interface" and "home interface," respectively.

## 2. SPECIFICATIONS

Report 1822 addresses two aspects of the connection of a host to the ARPANET, the hardware requirements and the software protocols. Since the JANUS interface will typically be used in applications other than connection to the ARPANET, the higher level software protocols are beyond the scope of this paper. They are properly addressed by documentation specific to each application. Concern here is only for electrical specification of the JANUS interface. The various areas which differ from Report 1822 are as follows.

### 2.1. Low-level Protocol

Certain aspects of the JANUS interface and its operation may be implemented in hardware, software of a mixture of the two. We refer to these aspects as "low-level protocol." They are to be distinguished from such "high-level protocol" aspects as header definitions and data formats.

#### 2.1.1. Padding

Requirement:
Received messages are padded out to a full word (of the home device's size), if necessary, with zeros only.

Discussion:
A one-bit to mark the end of received data, as IMPs employ, is NOT used. The mark bit has not proved very useful, although the ARPANET IMPs do use it to generate the message length field in the new format header. Rather, counts at one or another level of protocol are generally used, so the complication of a mark bit can be eliminated. It is the author's impression that the ARPANET will not implement this aspect of symmetrical interfaces, so hosts communicating through the ARPANET will continue to see the marker one-bit appended by the source IMP regardless of whether the hosts have 1822 or JANUS interfaces.

#### 2.1.2. Message Length

Requirement:
A JANUS interface must accept messages up to and including 8160 bits long.

Exception:
If the interface is absolutely never intended for use in ARPANET-compatible applications, this requirement may be relaxed in any of three ways. A smaller maximum length may be implemented; a larger maximum lengthbe implemented; or the maximum length may be so large as to be in practice infinite.

Discussion:
A JANUS interface may discard messages longer than 8160 bits when used with the ARPANET. This constraint can be enforced in software rather than in hardware, if desired.

2.1.3. Four-way Handshake

Requirement:
The interface must use the four-way handshake. That is, the receiver must wait until the incoming There's-Your-Bit drops before turning on Ready-For-Next-Bit.

Discussion:
The two-way handshake, presented as an option in Report 1822, must not be used. Experience has shown that it is vulnerable to various failures. First, if the off period in RFNB is not seen by the sender (due to noise or its being too short), a deadlock occurs and no more data is transferred. Second, a two-way receiver cannot talk with a strictly four-way sender, since the sender's next assertion of TYB may depend on seeing the RFNB transition to on. And third, the two-way handshake is overly sensitive to transitions, and may be activated by noise pulses. Transitions in the two-way handshake may be missed altogether in a sender implementation which samples the RFNB line only at certain intervals. The superiority of the more positive four-way handshake is important in applications where neither of the communicating interfaces is necessarily constructed to particular standards.

2.1.4. Contact Bounce

Requirement:
Each interface, considered together with the software driving it, must prevent data from flowing across the interface in either direction while its Ready relay contacts may be bouncing. Thus, for 1/10 second after raising Ready, the outgoing signals There's-Your-Bit and Ready-For-Next-Bit must not be asserted.

Discussion:
This may be accomplished either in hardware or software, as discussed in Report 1822 section B.3. The delay of 1/10 second is specified here to resolve an ambiguity in Report 1822, concerning whether a shorter delay was acceptable if the relay was known to solidly finish closing sooner.

Report 1822 specified a 1/2 second delay, but modern reed relays reliably finish closing in 1/10 second.

2.1.5. RFNB, TYB Minimum Off Time

Requirement:
Ready-For-Next-Bit must be off for at least 50 nanoseconds for local host connections, and at least 1 microsecond for distant host connections, as seen by the receiver of the signal (who is the sender of data). Note that this means that RFNB at the cable driver may have to be off for somewhat longer than this minimum if deterioration of the signal waveform along the cable is anticipated. There's-Your-Bit must similarly be off for at least 50 nanoseconds for local host connections, and at least 1 microsecond for distant host connections, as seen by the receiver of the signal.

Discussion:
This extends the Report 1822 requirements for signals received by the IMP, to both interfaces in a JANUS interface pair.

2.1.6. Deskewing

Requirement:
The outgoing data bit must be on the line and the Last-Bit level correct at least 500 nanoseconds before the sender turns on the There's-Your-Bit signal. The sender must turn off TYB before changing either the data or the LB.

Discussion:
The responsibility for deskewing signals rests with the sender in each interface. This applies the Report 1822 IMP sender behavior to each JANUS interface as a requirement. Note that the receiver may count on the Last-Bit signal being valid during, and only during, the assertion of There's-Your-Bit. Specifically, Last-Bit must be asserted during transmission of the last data bit. Report 1822 was slightly ambiguous in this regard.

2.1.7. Transmission Order

Requirement:
"The high-order bit of each word is transmitted first." (Report 1822, section 4.1.)

Discussion:
If a computer has addressing modes other than word addressing, such units or bytes are not used as units of transmission by the interface. For example, the first bit transmitted from or received into a PDP-11 is bit 15, the leftmost bit of a 16-bit word. This is repeated here to bring it especially to the attention of designers.

## 2.2. Distant Host Electrical Requirements

Discussion:
The paragraphs below specify a Distant Host option of the JANUS interface which differs substantially from the 1822 Distant Host interface. Several considerations prompted this change. Report 1822 specifies transformer coupling at the receiver, so requirements on signal rise time and hold times were made. To relax these, and to achieve greater tolerance to differences in ground potential, optical isolators are now often used, even in 1822 interfaces. Neither the Report 1822 Distant Host driver, nor the driver adopted for JANUS, generate more than 1.0 volt. Commonly available optical isolators require at least 1.1 volts to overcome their forward drop before they will operate. Thus an optical isolator driver is needed in both the 1822 and the JANUS receivers. The ground potential difference between the communicating interface may exceed the maximum ratings of the input amplifier, so the input circuit must be powered from a floating power supply. Appropriate DC-DC converters for this purpose are available at reasonable cost.

### 2.2.1. DH Signal Timing

Requirement:
Receiver circuits in distant host interfaces shall be implemented with optical isolators or other means which are not sensitive to rise and hold times, as transformer coupling is. Therefore, the requirements for rise and hold times on distant host signals appearing in Report 1822 are suspended.

### 2.2.2. DH Signal Levels and Waveforms

Requirement:
Signal levels and waveforms at the driver and the receiver shall follow the specifications in EIA standard RS-422. In particular, the driver must supply a differential of at least 2 and not more than 6 volts; and the receiver must operate correctly on as small a differential as 0.2 volts.

### 2.2.3. DH Electrical Isolation

Requirement:
The receiver circuit must operate correctly over a common mode voltage range of -100 to +100 volts, and must not be permanently damaged by a common mode voltage of from -300 to +300 volts.

Exception:
If the interface is absolutely never intended for use in an environment where common mode voltage exceeds 7 volts in magnitude, or where the voltage from either signal wire to the signal ground exceeds 10 volts in magnitude, then the electrical isolation required in this paragraph may be suspended, and the corresponding requirements of EIA specification RS-422 applied in its place. Such an implementation is explicitly an exceptional JANUS interface, and is not the standard JANUS interface.

Discussion:
A suggested way to achieve this isolation is an RS-422 receiver chip, such as the Motorola MC3487 or the Advanced Micro Devices Am26LS32, followed by an LED driver as needed, followed by an optical isolator such as the Hewlett-Packard 5082-4360. The receivers and LED drivers for all input lines may be powered from one source, but this power must be floated with respect to ground of the home interface.

2.2.4. DH Cable Shield Grounding

Requirement:
At each end the cable shield in a distant host connection shall be connected through a circuit described below to signal ground. The circuit consists of two components connected in parallel. (1) A 100K, 1/8 watt resistor provides a path to leak off slow accumulations of static charge.
(2) A .01 mfd, 600 V ceramic capacitor bypasses sharp noise spikes.

Exception:
In cases of severe noise, one end of the shield or the other (but not both!) may have to be tied directly to ground, sacrificing the symmetry.

Discussion:
Grounding the cable shield only at the host end, as in Report 1822, is undefined when the interface is symmetrical. Instead, the circuit above will be used.

2.2.5. DH Cable

Requirement:
Cable requirements in EIA specification RS-422 must be followed with respect to quality and electrical characteristics, and those in Report 1822 with respect to number of conductors. In particular, at least 10 twisted pairs with impedance of approximately 100 ohms must be supplied.

Discussion:
A suitable cable is PE-39, described in REA Bulletin 345-67. This cable is similar to that mass produced for telephone cable, which is of good, uniform quality, and readily available at reasonable cost. The cable specified in Report 1822 is not as desirable. Note the change in specified characteristic impedance: Report 1822 specified 120 ohms, while the JANUS interfaces follow RS-422 with 100 ohms.

2.2.6. DH Cable Termination

Requirement:
Termination shall be as specified in RS-422, in particular at the receiver. Termination as in Report 1822, at the driver, shall NOT be used.

Discussion:
The source-end termination specified in Report 1822 was to eliminate the voltage drop caused by the cable's series resistance. RS-422 explicitly allows for this sort of signal attenuation as a part of the specification.

3. STRONG RECOMMENDATIONS
3.1. Local Host Signal Levels

Suggested voltage levels for local host drivers and receivers are given below. The levels below are a combination of Report 1822 levels for 316/516 and Pluribus machines. The intent here is to be compatible with readily available TTL components. Suggested chips are the 7440 for a driver and the 7420 for a receiver. Note that signals may go up to 6 volts, which may damage receiving circuits constructed of normal 5-volt logic. Such receivers should have a voltage divider on their inputs.

| | | | | | |
|---|---|---|---|---|---|
| driver output voltage | | | | | |
| with input = 0: | - | min, | 0.35 | max | (0.07 typical) |
| with input = 1: | 3.5 | min, | 6.0 | max | (5.0 typical) |
| receiver input voltage | | | | | |
| to assume a binary 0: | 0.6 | min | (0.9 | typical) | |
| to assume a binary 1: | 2.5 | max | (1.7 | typical) | |
| maximum input rating: | 6.0 | max | | | |

Cable impedance and termination circuits are covered in Report 1822. With properly chosen cable and well designed circuits, and with impedances matched, local host connections may operate considerably farther than the 30 feet given in Report 1822. Cables as long as 300 feet are in use communicating with ARPANET IMPs. For example, 300 foot cables have worked using 7440's as drivers, standard TTL gates as receivers, cable termination (on all signal lines) of a diode to ground and a diode to +3 volts, and RG174/U cable. RG174/U is 50 ohm coax, and a 100 ohm coax is preferred, to reduce ringing.

### 3.2. Use of the Ready Line

It is strongly recommended that the Ready Line provided by the hardware be used by the software in a manner similar or identical to that described in Report 1822. Report 1822 sections 3.2, 4.4 and Appendix B especially bear on this topic. In particular, the software design should provide for the following:

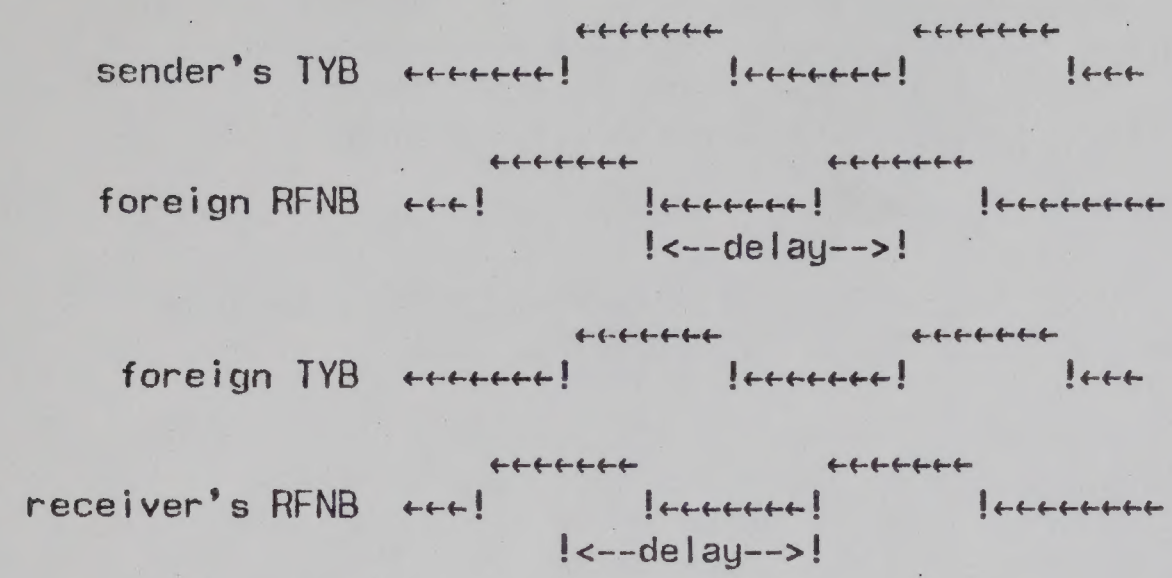
(1) A ready indicator (relay) which tells the foreign interface that the home interface and software are ready to communicate.

(2) An "error" flip-flop which tells the home software that the foreign interface has been not ready.

(3) NOP messages which are used to purge the communication "pipe" after the ready line has "flapped" down and back up.

## 4. ADVICE ON DELAYS TO LIMIT BANDWIDTH

It is advisable to include adjustable delays whose function is to limit the maximum bandwidth of transfers, as discussed in Report 1822. Only when the details (such as cable characteristics, memory speed, and acceptable memory utilization) of a specific application guarantee that an unregulated transfer rate will be acceptable can these delays be omitted. Two delays are involved, one in the sender circuit and one in the receiver circuit. The sender delays up to 10 microseconds (adjustable) from when the foreign interface drops Ready-For-Next-Bit, before again turning on There's-Your-Bit. (This is the sum of delays C and D in Report 1822 Fig. B-1.) The receiver delays up to 10 microseconds (adjustable) from when the foreign interface asserts There's-Your-Bit, before again turning on Ready-For-Next-Bit. (This is the sum of delays A and B in Report 1822 Fig. B-2.) When delivered, interfaces should have these delays set at approximately the maximum delay. The timing is shown below.




## 5. INTER-OPERABILITY WITH 1822 INTERFACES

Protocol specifications have been chosen which are compatible with Report 1822. Actually, the protocol areas discussed above are further clarification of Report 1822, rather than any change from it. The electrical specifications differ only slightly from the 1822 interface. The local host levels chosen are 1822 compatible. The potential difficulties in using a JANUS interface cabled to an 1822 interface arise with the distant host interface.

The distant host cable for a JANUS interface is 100 ohms nominal impedance, compared to 120 ohms for the 1822 interface. This difference is small enough that most applications will work with either cable, or even with some 100 ohm cable and some 120 ohm cable.

The 1822 distant host interface does not provide as much electrical isolation as the standard JANUS distant host interface. Thus, in cases of severe common mode noise or ground potential difference, two JANUS interfaces might operate correctly, but an 1822 interface might misbehave or burn out.

The JANUS distant host driver yields 2 to 6 volts output, and its receiver requires 0.2 volts input; the 1822 distant host driver yields 1.0 volt output, and its receiver requires 0.1 volt input. Unless there is a significant signal loss in the cable, the 1822 driver will drive a JANUS receiver acceptably. On the other hand, the maximum input to an 1822 receiver is 4.0 volts. Thus a JANUS driver might overdrive an 1822 receiver. The simplest fix for this is to put a (balanced) voltage divider at the 1822 receiver, or at the JANUS driver. The divider should cut down the maximum voltage from 6 volts to 4 volts, or a reduction of 1/3.

The above differences are relatively minor, so in most applications an interconnected 1822 interface and a JANUS interface should operate correctly. Attention must be paid to the electrical isolation susceptibility of the 1822, and to its maximum input voltage.

## 6. MILITARY COMPATIBILITY

The EIA specification RS-422 chosen as a base for the JANUS interface distant host electrical characteristics is compatible with military specification MIL-188-114.

The common mode voltage tolerance of the JANUS interface provides significant protection against widely varying ground potentials in field equipment separated by distances of thousands of feet.

## 7. REFERENCES

"Specifications for the Interconnection of a Host and an IMP," BBN Report 1822, revised January 1976; BBN Inc., 50 Moulton St., Cambridge, Ma. 02138.

"Electrical Characteristics of Balanced Voltage Digital Interface Circuits, EIA standard RS-422," April 1975; Engineering Dept., Electronic Industries Assn., 2001 Eye St., N.W., Washington, D.C., 20006.

REA bulletin 345-67, Rural Electrification Admin., U.S. Dept. of Agriculture. Contains specification for PE-39 cable.